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(54) Filtration device with fluid tight seal

(57) A filtration device comprisies at least two constructional; elements which are mated together to form an edge, and is characterised in that at least a part of the said edge is fluid tight sealed with and ethylene-vinyl acetate copolymer positioned between the elements. The elementa may be parts of a housing of the filter or as exemplified in detail, a filter membrane and its support, where the seal is along the edges of the two.

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FILTRATION DEVICE

The present invention relates to filtration devices, particularly filtration devices involving one or more supported membrane assemblies.

Filtration devices typically involve structural elements which must be fluid-tight sealed to control fluid flow therethrough and to prevent leakage, e.g., to ensure the absence of fluid pathways which bypass the filtration medium within the filtration device. This is a particularly significant problem in filtration devices which contain multiple fluid pathways, multiple filtration media, and/or motive means, such as in dynamic filtration. Many such filtration devices incorporate a series of supported filtration medium assemblies comprising a filtration medium mated with a support material, wherein fluid pathways may exist between the filtration medium and support material or between adjacent support materials of back-to-back supported filtration medium assemblies.

A variety of sealant and gasket materials have been used between the filtration medium and support material of a supported filtration medium assembly, as well as between adjacent support materials of back-to-back supported filtration medium assemblies, so as to control fluid flow and prevent leakage. Such materials include polyurethane which can provide fluid-tight seals but suffers from high extractables which can contaminate the fluid being filtered. Other materials with low extractables, such as polyethylene, however, can be brittle and can have little compliance, thereby allowing for fluid leakage pathways, particularly in filtration devices with motive means, such as dynamic filtration devices.

Thus, there remains a need for a filtration device utilizing fluid-tight seals with relatively high compliancy and low extractables. The present invention seeks to

provide such a filtration device. These and other objects and advantages of the present invention, as well as additional inventive features, will be apparent from the description of the invention provided herein.

The present invention provides a filtration device comprising at least two structural elements which are mated together to form an edge, at least a portion of the edge being fluid-tight sealed with a copolymer of polyethylene and ethylene vinyl acetate positioned between the structural elements. The present invention also provides a filtration method comprising filtering a fluid through the present inventive filtration device.

Any suitable copolymer of polyethylene and ethylene vinyl acetate can be utilized in the context of the present invention. The copolymer desirably has a softening and/or melting temperature below that of the mated structural elements being fluid-tight sealed with the copolymer. Preferably, the copolymer is the 10SE (Registered Trade Mark) product available from Oliver Products Company (Grand Rapids, Michigan).

Any edge or portion thereof of any suitable mated structural elements of a filtration device can be fluid-tight sealed with the copolymer. Such structural elements can be, for example, portions of a filtration housing, two filtration media, a filtration medium and a support material, or two support materials. More typically, such structural elements will be portions of one or more supported filtration medium assemblies, each of which comprises a filtration medium, usually a membrane, and a support material, wherein the copolymer typically will be utilized as a gasket to fluid-tight seal edges or portions thereof between the filtration medium and support material of individual supported filtration medium assemblies and/or between the support materials of adjacent support materials of back-to-back supported filtration medium assemblies.

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Any suitable filtration medium can be used in the context of the present invention. The filtration medium is preferably a porous membrane. Suitable membranes include microporous membranes (e.g., membranes generally having pore ratings of about 20 nm to about 100 μm or more), ultrafiltration membranes (e.g., membranes generally having pore ratings of less than about 20 nm), nanofiltration membranes, and reverse osmosis membranes. The membrane may be prepared from any suitable material, such as metals, ceramics, and polymers. Suitable metallic membranes can be prepared from materials which include steel, e.g., stainless steel, and nickel. Stainless steel membranes are commercially available as PMM (Registered Trade Mark) Metal Membrane Filters (Pall Corporation, East Hills, New York). Preferably, the membrane will be a polymeric membrane. Suitable such membranes can be prepared from polymeric materials such as polyamide, polytetrafluoroethylene, polyvinylidene fluoride, polyethersulfone, polyethylene, and polypropylene. More preferred membranes are polyamide, e.g., nylon, and polytetrafluoroethylene membranes, with the most preferred membrane being a polytetrafluoroethylene membrane. The preparation of polymeric membranes is generally described in, for example, U.S. Patent 4,340,479, and such membranes are commercially available under a variety of trademarks, such as Ultipor (Registered Trade Mark of Pall Corporation, East Hills, New York).

The support material can be any suitable material, desirably a material that is more rigid than the filtration medium, e.g., having a flexural rigidity (ASTM D 1388-64 (reapproved 1975; editorial changes in 1975 and 1976) cantilever test) at least about 10 times, preferably at least about 50 times, more preferably at least about 100 times, e.g., about 500 times or more, and most preferably at least about 1000 times, the flexural rigidity of the filtration medium. The support material also preferably has a tensile strength at least about 5 times, more

preferably at least 10 times, and most preferably at least 20 times, the tensile strength of the filtration medium.

The support material will be typically a polymeric material or a metal. Suitable polymeric materials include polyamide (e.g., nylon), polypropylene, polyethersulfone (PES), polysulfone (PSO), polyetherimide (PEI), polyetheretherketone (PEEK), and polyetherketone (PEK). Suitable metallic materials include metals, such as aluminum, and alloys, such as stainless steel. The support material can be in any suitable form, e.g., sheet, fibrous, mesh, and the like.

The support material can be porous, such that the filtered fluid flows through the support material, or fluid-impermeable, e.g., nonporous, such that the filtered fluid flows laterally between the filtration medium and the support material. The support material is preferably a stainless steel porous sheet, e.g., with chemically etched holes therethrough.

The support material can also be a filtration medium, such as a membrane. Thus, two filtration media of the same or different compositions or configurations can be mated together to form an edge, with at least a portion of the edge being fluid-tight sealed with a copolymer of polyethylene and ethylene vinyl acetate positioned between the filtration media. In such embodiments, the filtration medium and support material are preferably the same. This can be accomplished by utilizing two filtration media of the same composition and configuration or by folding over a single filtration medium which can be mated to itself. In embodiments where a filtration medium is mated with another filtration medium (either another distinct filtration medium or a portion of itself), fluid may flow through one of the filtration media and then the other filtration medium sequentially, although it will be more usual that fluid will flow through both of the filtration

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media simultaneously into the space between the filtration media whereupon the fluid will then flow laterally between the filtration media until reaching a suitable outlet.

The filtration medium and/or support material can be rendered more amenable to adherence to the copolymer by any suitable technique. For example, metal surfaces can be roughened, e.g., by etching and/or subjecting the surface to heat-treatment or other oxidative surface treatment.

A diffusion layer is desirably positioned between a filtration medium mated with any other filtration medium and/or a support material, particularly when the support material is fluid-impermeable so as to enhance lateral fluid flow between the filtration medium and the support material. A diffusion layer also may be desirably positioned between a filtration medium and a porous support material, particularly if the support material is rigid and has a smooth surface, such as a porous metal plate, so as to minimize the pressure drop across the supported filtration medium assembly. Similarly, a diffusion layer is desirably positioned between adjacent support materials of back-to-back supported filtration medium assemblies, especially when the support materials are porous, so as to enhance lateral fluid flow between the support materials.

The diffusion layer can be of any suitable configuration and material which allow for, and preferably assist in, the lateral or edgewise flow of the fluid between the surfaces adjacent thereto. Suitable configurations for the diffusion layer include polymeric or metallic, e.g., wire, meshes, woven materials, and fibrous nonwoven webs. Suitable materials for the diffusion layer include polymers such as polypropylene, polyethylene, polytetrafluoroethylene, nylon, and polyester, and metals such as aluminum and stainless steel. The diffusion layer is porous so as not to interfere with fluid flow and, preferably, so as not to substantially contribute to the pressure drop across the filtration device. The diffusion

layer preferably has a high voids volume. In addition, the diffusion layer preferably has a Frazier number at least about two times, and preferably at least about four times, the Frazier number of the filtration medium. The diffusion layer can be of any suitable thickness, e.g., about 25-125 μm thick to about 250-500 mils thick or greater.

Preferred embodiments of the present invention include the following filtration devices. In one preferred embodiment of the present inventive filtration device, the structural elements are supported membrane assemblies comprising a membrane and a porous support material, such that the support material of at least one of the supported membrane assemblies is mated with the support material of another of the supported membrane assemblies to form one or more edges which are partially but not completely fluid-tight sealed with the copolymer positioned between the support materials, and the filtration device further comprises a diffusion layer positioned between the mated support materials. In such a filtration device, the support materials are preferably doughnut-shaped so as to form two concentric edges with only one of the edges being fluid-tight sealed with the copolymer positioned between the support materials and the other of the edges allowing for the passage of fluid therebetween. The diffusion layer in such an embodiment is preferably a fibrous nonwoven web or a polymeric or metallic mesh, and the diffusion layer is further preferably partially embedded in the copolymer positioned between the membrane and the support material.

In another preferred embodiment of the present inventive filtration device, the structural elements are a membrane and a porous support material, and the membrane and the support material are mated together to form one or more edges, all of which edges are fluid-tight sealed with the copolymer positioned between the membrane and the support material. Such a filtration device further preferably comprises a diffusion layer positioned between the membrane and the support material.

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In an additional preferred embodiment of the present inventive filtration device, the structural elements are a membrane and a fluid-impermeable support material, the membrane is mated with the support material to form one or more edges which are partially but not completely fluid-tight sealed with the copolymer positioned between the membrane and the support material, and the filtration device further comprises a diffusion layer positioned between the mated membrane and the support material. The membrane and the support material are preferably doughnut-shaped so as to form two concentric edges with only one of the edges being fluid-tight sealed with the copolymer positioned between the membrane and the support material and the other of the edges allowing for the passage of fluid therebetween. The diffusion layer in such an embodiment is preferably a fibrous nonwoven web or a polymeric or metallic mesh, and the diffusion layer is further preferably partially embedded in the copolymer positioned between the membrane and the support material.

In such preferred embodiments, or other embodiments, of the present invention, the filtration device can contain multiple fluid pathways, e.g., feed and/or permeate holes, through the filtration media, diffusions layers, and/or support materials to direct fluid flow into the filtration device, through the various filtration media, and out of the filtration device. In such embodiments, the copolymer can act as a gasket by being suitably positioned around each such fluid pathway, e.g., around a feed hole through a diffusion layer, so as to avoid contamination between the various fluid streams during operation of the filtration device. Thus, the copolymer can act as a gasket to replace conventional gaskets in any appropriate filtration device.

The present inventive filtration device can be used for any suitable purpose, e.g., for any purpose for which a conventional filtration device could be used. Since the present inventive filtration device has excellent adhesion

and compliance characteristics combined with a relatively low level of extractables, the present inventive filtration device can also be used in applications and environments in which a conventional filtration device may not be suitable, such as in high pressure, high shear, or pulsed flow environments involving fluids which could cause a high degree of extractables. The present inventive filtration device is useful in crossflow filtration devices and applications and is particularly well-suited in dynamic filtration devices and applications, especially those involving rotary and vibratory dynamic filtration devices.

The present inventive filtration device, in particular the mated and fluid-tight sealed structural elements, preferably can withstand shear rates, such as encountered in dynamic filtration, of at least about 200,000 sec^{-1}, more preferably of at least about 400,000 sec^{-1}, and most preferably of at least about 500,000 sec^{-1}. Similarly, the present inventive filtration device desirably can withstand filtration and backflow pressures of at least about 100 kPa, preferably at least about 200 kPa, more preferably at least about 400 kPa, and most preferably at least about 500 kPa.

The present invention also provides a method of filtering a fluid, which method comprises passing a fluid through the filtration device of the present invention. Any suitable fluid, particularly a liquid, can be so processed in accordance with the present invention.

While this invention has been described with an emphasis upon preferred embodiments, it will be obvious to those of ordinary skill in the art that variations of the preferred embodiments may be used and that it is intended that the invention may be practised otherwise than as specifically described herein. Accordingly, this invention includes all modifications encompassed within the scope of the invention as defined by the following claims.

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CLAIMS

1. A filtration device comprising at least two structural elements which are mated together to form an edge, at least a portion of said edge being fluid-tight sealed with a copolymer of polyethylene and ethylene vinyl acetate positioned between said structural elements.

2. The filtration device of claim 1, wherein said structural elements are a filtration medium and a porous support material, and said filtration medium and said support material are mated together to form one or more edges, all of which edges are fluid-tight sealed with said copolymer positioned between said filtration medium and said support material.

3. The filtration device of claim 2, wherein said filtration device further comprises a diffusion layer positioned between said structural elements.

4. The filtration device of claim 1, wherein said structural elements are supported filtration medium assemblies comprising a filtration medium and a porous support material, said support material of at least one of said supported filtration medium assemblies is mated with said support material of another of said supported filtration medium assemblies to form one or more edges which are partially but not completely fluid-tight sealed with said copolymer positioned between said support materials, and said filtration device further comprises a diffusion layer positioned between said mated support materials.

5. The filtration device of claim 4, wherein said support materials are doughnut-shaped so as to form two concentric edges with only one of said edges being fluid-tight sealed with said copolymer positioned between said support materials and the other of said edges allowing for the passage of fluid therebetween.

6. The filtration device of claim 1, wherein said structural elements are a filtration medium and a fluid-impermeable support material, said filtration medium is mated with said support material to form one or more edges which are partially but not completely fluid-tight sealed with said copolymer positioned between said filtration medium and said support material, and said filtration device further comprises a diffusion layer positioned between said mated filtration medium and said support material.

7. The filtration device of claim 6, wherein said filtration medium and said support material are doughnut-shaped so as to form two concentric edges with only one of said edges being fluid-tight sealed with said copolymer positioned between said filtration medium and said support material and the other of said edges allowing for the passage of fluid therebetween.

8. The filtration device of any of claims 3-7, wherein said diffusion layer is partially embedded in said copolymer positioned between said filtration medium and said support material.

9. The filtration device of any of claims 1-8, wherein said filtration device further comprises dynamic filtration means.

10. A filtration method comprising filtering a fluid through the filtration device of any of claims 1-9.

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The Patent Office

Application No: GB 9610296.7 **Examiner:** John Wilson
Claims searched: 1-10 **Date of search:** 19 August 1996

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Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

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Int Cl (Ed.6): B01D 61/10 61/12 61/20 61/22 65/00 67/00 69/00

Other: Online:- WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
Y	GB1415873	Sandoz - see p.2 ll.62-65	1 at least
X,Y	EP0457676A2	Eurodia - note col.3 ll.30-37 in particular	1,2 at least
X,Y	EP0174420A2	Shiley Inc. - note p.11 ll.7-22	1 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.